



Mining and environment in Nigeria: the past, the present and the future

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General Note

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ABSTRACT

Mining of natural resources which range from metallic to non-metallic is as old as the age of man on the surface of the earth. This activity is being done on different scales such as artisanal/illegal mining, small scale mining and large scale mining. The exploitation of these natural resources has been done in the past (>50 years) using crude tools such as diggers, shovels, hammers with no geological or geophysical survey and environmental impact assessment. The introduction of machines like excavators and pay-loaders with some geological geophysical and/or geochemical survey without adequate environmental impact assessment characterize the mining business today. Both in the past or in the present, mining has some effects on the environment and these

include ecological disturbances, socio-economic effects and pollution. These effects may range from temporary to permanent. This work presents the cases of mining activities in Kwara and Oyo States of Nigeria with their effects on the environment highlighted. It also evaluates the likely future effects of mining on the environment. It is recommended that the government should help in creating the enabling environments for the mining business to thrive; remove bottle-necks from procedures in securing the required mining documents by the miners. In addition, miners should be grouped into cooperatives to make for efficient supervision and management. Furthermore, the miners should be effectively educated on the best practices in mining. In conclusion, if all aforementioned are effected, the negative effects of mining on the environment will be greatly reduced.

Keywords: Mining, Environmental impact, Nigeria, Natural Resources, The Future

1. INTRODUCTION

Environment can be described as all external factors affecting an organism. These factors may be biotic or abiotic. The biotic components are the living things which include the floral and the fauna. Both the floral and the fauna depend directly or indirectly on the abiotic (non-living) for their survival. These abiotic include land, air, and water. The process of getting the needed minerals from the environment takes place by extraction of all from mining activities. To the miners, a mineral is anything that can be won from the earth and exchanged at a profit. Mining dates back to the period of human existence while the minerals mined range from non-metallic like sand, limestone and talc to metallic minerals like cassiterite, gold and iron.

The act of mining in general is environmentally unfriendly and has attracted attention from the standpoint of environmental impact and their mitigation. The impact of mining affects all the components of the environment directly or indirectly. These effects can be permanent or temporary, beneficial or harmful, reparable or irreparable and reversible or irreversible such as interruptions and other changes in natural conditions that cause ponds, fluctuations of groundwater level, alterations to stream flow characteristics, and soil erosion and siltation, changes in water turbidity, suspended load and increase in temperature; increase in chemical pollutants such as heavy metals, salt and insecticides; changes in vegetation caused by site clearing and alterations of the systems in the natural region (Jiya and Musa, 2012).

At present, Nigeria cannot be described as a mining nation because most of the mining activities carried out in this country are done mainly by artisanal or illegal miners. The total input of mining to national GDP is <2% though oil exploitation contributes the larger percentage of this. In addition, no world class deposit has been discovered in this nation.

This work therefore aims at evaluating the likely future impact of mining on the environment based on what was obtainable in the past and what is seen presently. This work also attempts to offer solution to reduce the effects of mining on the environment in Nigeria in the future.

The approach used in this work is interpersonal communication and literature review. Some miners were interviewed to obtain information about the mining activities in the past and the present and what is likely to happen in the future.

2. GEOLOGY OF NIGERIA

The Geology of Nigeria comprises the Basement Complex, intruded by the Younger Granites and overlain unconformably by the sedimentary basins (Fig. 1).

The Basement Complex rocks include the Migmatite-Gnesis complex believed to be the oldest, the schist belts (metasedimentary and metavolcanic rocks) which have been subjected to series of deformations and the Pan-African Granitoids (Older Granites and associated charnockitic rocks). The Younger Granites were emplaced into the Basement Complex in the Triassic – Cretaceous (mostly Jurassic) Age. They are formed as a result of alkaline anorogenic magmatism and occur as ring complexes. The Younger Granites are overwhelmingly acidic and rich in tin mineralization. Other basement rocks are Tertiary-Recent volcanic rocks formed from volcanic activity that took place intermittently from Tertiary to Recent times. The most extensive outcrops are in the Biu and Longuda plateaux of north-eastern Nigeria, on the Jos Plateau and in the Benue Trough.

Sedimentary basins overlie the Basement Complex unconformably. They include Chad basin in the northeastern part, Sokoto basin in the northwestern part, Benue Trough, the Bida Basin and Anambra Basin (basins associated with river Benue and river Niger), Dahomey basin in the southwestern part and the Niger Delta in the southern part of the country.

The geological terrain of Nigeria is similar to that of Ghana and other countries where many minerals have been exploited and are still being exploited. The regions of metallic mineral occurrences in Nigeria are shown in Fig. 2. Each of the states in Nigeria has one mineral occurrence or the other (Table 1) hence all the states in Nigeria are affected by the activities of miners in the country.

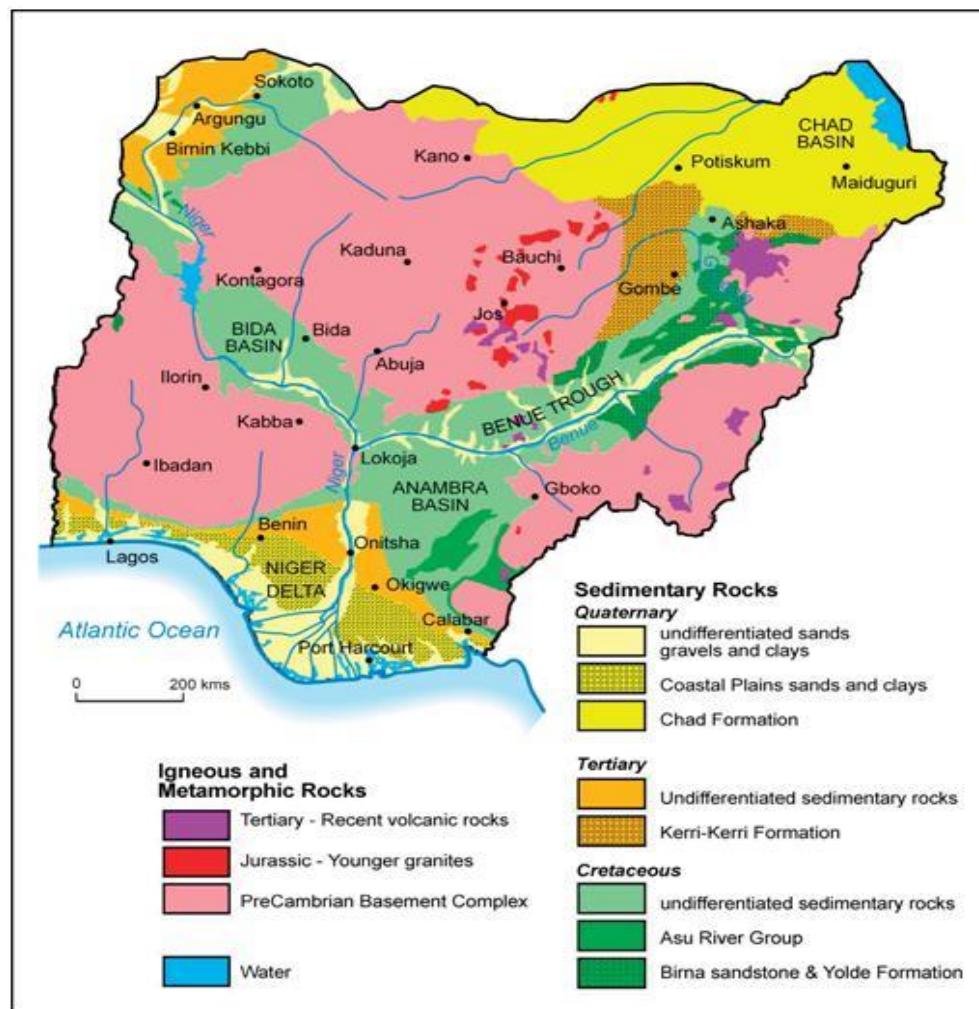


Figure 1 Geological Map of Nigeria (Adapted from Malomo, 2012)

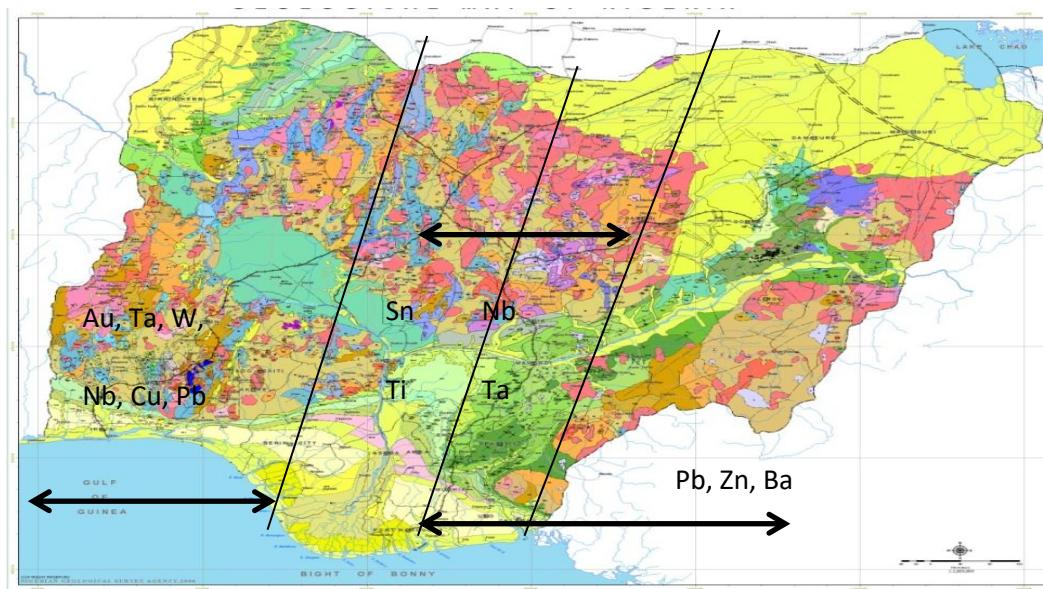


Figure 2 Metallogenic (Mineral Bearing) Provinces (Adapted from Malomo 2012)

Table 1 List of minerals in Nigeria and their uses (Adapted from Malomo, 2012)

Mineral Name	Location(s) in Nigeria
Tin	Plateau, Bauchi, Kano, Kaduna, Kwara, Nasarawa
Lead/Zinc	Benue, Ebonyi, Plateau, CRS, Zamfara& FCT
Titanium	Kaduna, Bauchi, Plateau, CRS &Anambra
Aluminum	Ekiti&Taraba (occurrences recorded)
Copper	Nasarawa; Traces recorded in FCT &Bauchi
Lithium	Nasarawa, Kaduna, Niger &Zamfara
Tungsten (Wolframite)	Kano, Kaduna, Bauchi, Niger, Kwara, Zamfara & Nasarawa
Limestone	Sokoto, Gombe, Benue, Kogi, Edo, Oyo, Ogun, CRS, and Ebonyi
Marble	Kogi, Nasarawa, Oyo, Kwara, Edo, FCT
Barytes	Nasarawa, Plateau, Taraba, Benue, Cross River
Gypsum	Yobe, Adamawa, Ogun, Gombe, Sokoto, Edo
Bentonite	Edo, Kogi, Ogun, Ondo, Borno
Talc	Kogi, Kaduna, Niger, Ekiti and Kwara
Kaolin	Ogun, Kogi, Bauchi, Kebbi, Rivers, Anambra, Katsina , Ondo, Akwa-Ibom, Imo, Plateau, Kwara
Sillimanite	Oyo, Ogun, Kaduna
Graphite	Taraba, Kaduna and Zamfara
Feldspars	Borno, Kogi, Kaduna and FCT
Mica	Kogi, Ekiti, Nasarawa, Kwara and Oyo
Graphite	Taraba, Kaduna and Zamfara
Feldspars	Borno, Kogi, Kaduna and FCT
Mica	Kogi, Ekiti, Nasarawa, Kwara and Oyo

3. SCALE OF MINING OPERATIONS

Mining activities in Nigeria has been done on several scales such as illegal/ artisanal mining, small scale mining and large scale mining.

Artisanal/Illegal Mining: Illegal mining activities involve all mining operations carried out in the absence of mining license, exploration permit or any document that could legitimate the mineral extraction processes. On the other hand, artisanal mining may be legal or illegal but describes mining exercise involving the use of simple tools on a subsistence level. Most artisanal and illegal mining take place in low grade area or abandoned mining sites. Low productivities and limited production are therefore their main characteristics.

Adekeye (2010); Charkravorty (2001); Gunson and Yue (2001); Jennings (2001) and MMSD (2001) have said that artisanal and illegal mining are characterized by lack of or much reduced degree of mechanization, great physical labour with little or no safety measures put in-place. Other characteristics are: low recovery values, exploitation of marginal ores, deficient qualification of the personnel on all levels of operation etc.

Small Scale Mining: Though there is no universally accepted definition of small scale mining (SSM), SSM is commonly associated with informal, unregulated, undercapitalized and under-equipped operation where technical and management skills are lacking. They are also believed to erratically produce limited amount of minerals from uncertain reserves. The small scale miners are also nomadic in nature moving together from one place to another in search of mineral or natural resources. Artisanal and illegal mining are often grouped as component of SSM (Adekeye, 2010; Benjamin et al., 2003).

Large Scale Mining: This usually involves a company with many employees often in excess of a thousand people. The company mines at one or more large sites until the mineral is depleted. This type of mining often requires large capital as evidenced in the use of relatively more machines.

4. MINING AND ENVIRONMENT IN NIGERIA: THE PAST

Mining in Nigeria is an age long activity believed to have started with the NOK culture in northern Nigeria (Mallo, 2007). Though it can be traced to all inhabitants of the nation, the extraction of placer tin ore (cassiterite) dates as far back as 900BC in rivers like Delimi, Jaura and Asop making the people of NOK unique in mining. These rivers have their sources in Jos area of Plateau State, Nigeria. Other metallic minerals extracted around this period across the nation are iron ore and precious metals like gold. The bulk of gold exploit in Nigeria in the early days (1914 - 1955) came from areas like Niger, Kaduna, Sokoto and Zamfara (Nnabo and Taiwo, 2001). Gold exploitation started in Kabba area in 1935 and then Benin and Ilesha in 1941. Gold exploitation flourished between 1933 and 1942 in Nigeria as a result of the decline in price of tin in the London Metal Exchange (LEM). Lead exploitation started with the natives of the host community in Abakaliki. These natives exploited the lead mainly for use as cosmetics and to obtain lead. The extraction was done with the aid of digging implements. The mining methods used included open excavation with irregular tunneling. The oxidized sulphide lodes were won easily with the crude tools while the siliceous lodes that were relatively too hard and contain lesser amount of iron and galena were not exploited. The exploitation of these metals and other minerals led to the establishment of some camps around Zurak, Arufu and Abakaliki before World War I (Nnabo and Taiwo, 2001).

Coal was first discovered along the foot of Udi hill in Enugu in 1909 by British geologists (Diala, 2003; Ugwu, 2003) while the actual mining started in 1915 along the escarpments of Enugu. The convectional mining methods using pillar and stall were employed mainly. The exploited coal was also loaded into the mine cars manually. Coal exploitation reached its peak production of 905,397 tones in the late 1950's (Ugwu, 2003) but came to a halt during the civil war. During these past years, four mines were in operation. These are Okpara underground mine in Enugu State, Okaba mine, Ugwu Onyeama coal mine in Enugu and open cast mine in Benue State. The extracted coal was used in powering the ships, railway and also in energy/electricity generation. Other usage was in cooking. While these were on-going, the non-metallic minerals like clay, sand and rock were mined for construction purposes. These quarrying and mining were done basically using hoe, digger and shovel. All these minerals were discovered accidentally either because they occur at or close to the surface of the earth. In most cases, the reserves of extracted minerals were not proven. Traditional methods of refining or processing the extracted minerals were employed by the miners with no environmental issues considered. Furthermore, few people were into the business, the miners were not mobile and earned no wages. Some received their daily meal or need as compensation for the hard day's work. Other peculiarity of the early miners was that the work was poverty driven or farming holiday business. Gold production began in 1913 and reached its peak in the 1930s (Nnabo and Taiwo, 2001).

Mining in Nigeria started as artisanal/illegal type but with the sole aim of providing raw materials for the building and fabrication of farm implements and weapons. The commercial trading of tin product in places like Kano, Ilorin and Lagos was also carried out in the 18th Century. Some of this product was sold outside the country and as a result, attracted the interest of foreign miners e.g. Royal Niger Company (RNC). RNC came into mining around 1902 by tracing the primary source of the placer tin mined in the Delimi River to the Plateau. The company later set up a camp at Naraguta near Jos. The success of this company attracted other companies like the British and European Mining Companies which exploited the best available reserves. The mine area in the Plateau area spans 240km X 120km (Mallo, 2007). It can then be said that at the inception, the mining activities in Nigeria is of artisanal/illegal and large scale mining (peak production = 15,842 tons).

The impacts of the mining exercise during this period included land and earth surface degradation and deforestation. Other effects of mining on the environment included pollution of the environment with noise, mine tailings etc. Social-economic wise, people moved across the nation to the mining areas to take part in the mining exercise. This led to the increase in the standard of living with the attendance outbreak of diseases and social vices. While the economic conditions of the mine communities were boosted, some communities lost their identity to the mining activities. This is particular the case of Okaba coal mine which is hosted by Odagbo community. The Odagbo community is never heard of but Okaba, a nearby settlement believed to have influential people is known for mining activity at the expense of Odagbo (Nigeriandaily.com, Feb. 26, 2011). Conversely, some of the communities became known e.g. Jos. Ezeigbo and Ezeanyim (2006) recognized reactivation of the fractured Enugu coal mines formation, the major fault and the criss-cutting minor faults in this area as a potential environmental hazard that is related to coal mining. The atmosphere is also polluted with noxious gases like H₂S, CO, CH₄ and oxides of sulphur and nitrogen associated with the burning of coal spoil.

5. MINING AND ENVIRONMENT IN NIGERIA: THE PRESENT

Following the collapse in the price of tin at the LME in the late 1950s, the mining companies in the Plateau area where most of the relatively large scale mining was taking place folded -up giving room for the artisanal and illegal miners. The products of the artisanal and illegal miners in Nigeria started with panning for the tin mineral in the Jos area. Adekeye (2010) described these miners

to extract broad range of minerals. Generally, they produce minerals that are easily won, transport and sell legally or illegally. Such minerals include tourmaline, gold, garnet, beryl, amethyst and gemstones. Other minerals are columbite, tantalite, sphalerite/galena, phosphate, barite, kaolin, shale (bicarbonate), sand, laterite and fossil among others. These minerals are sought across the nation and extracted essentially with little or no attention being paid to the environmental impact depending on the ease of their acceptance by the host community. Surface mining today is characterized by very large equipment, and modern technology for planning, designing, monitoring and controlling operations.

It is worth noting that most people who are going into mining nowadays do so with the aim of being self-employed as against being hired as practiced in the past. The miners are more mobile with agreed wages, if need be, to work for a set of miners. The ease of discovering the deposit is also harder and hence the use of more machines in the extraction exercise. The miners are also becoming legal and are semi-skilled. Atmospheric weather is not a limiting factor. Other mining activities in Nigeria now can be classified as SSM. Their products include marble quarrying, limestone, granite and manganese.

The SSM sought permission from both the Federal Government and local people and carried out Environmental Impact Assessment (EIA), social-economic amenities are often provided for their host communities but the EIA is rarely adhered to. The effect of their mining activities can be broadly divided into primary and secondary. The primary effect of mining which impacts the environment directly are deforestation, landscape destruction, garbage and solid waste, cyanide pollution, direct dumping of tailing and effluent into rivers, noise pollution etc. The deforested area will be subjected to the harsh effect of whirlwind or storm. The destroyed landscape allows percolation of water during rainfall and acts as breeding ground for mosquitoes and similar insects. This subsequently aids the spread of malaria parasite in the area. The dumped wastes also reduce the fauna in the environment. The other secondary effect is death that is often associated with the lead poisoning, cyanide and those associated with the shock caused by blasting, flying stones, etc. The waters are mostly disturbed and polluted thereby becoming unsafe for human use. Violence and agitation is one of the most pronounced effects of mining nowadays across the length and breadth of the nation. Social-economic impact, for example, that between Egbe in Kogi State and Share in Kwara State over a marble deposit at the boundary of the two communities. Land use conflicts, hostile relationships with neighbours and communities are also part of the attending issues.

Advances in numerical modeling, seismic monitoring and rock-mass characteristics have contributed immensely to the evolution of modern ground-control design services, thereby solving the problems of mine design and rock engineering that are complicated by the difficulties of characterizing rock and rock-mass behavior, in homogeneity, fractures, *in-situ* stresses, induced stress and groundwater. The increasing scale of mining operation and equipment, coupled with the greater depths of mining and higher extraction rates, will require improved procedures for ground-control design and monitoring.

6. MINING AND ENVIRONMENT IN NIGERIA: THE FUTURE

"Mining is only struggling with the lost battle, recycling holds the future of material production in Nigeria" in-line with the above quotation and the degree of awareness and education of the Nigerian citizen, the mining activities in Nigeria will not be towards the extraction of just a mineral but mining proven deposits. Two of the miners interviewed have this concerning exploration and exploitation of minerals in Nigeria. Mr. Jimmy said 'I am not interested in employing explorationist, the Whiteman used one equipment during our last surveying. He rolls it just like a ball and on getting to the deposit, the equipment just stopped, can you help me get this'. It is often said that if you can think it, you can get it; this shows that in the nearest future, the artisanal/ illegal miners will not be exploiting based on hide and seek principle combing the whole area with their shovel and digger but will be site specific and definite in their exploration. Another miner that is interested in gold; Mr. Olakorede said 'there is one equipment that when you put any mineral on it, it will tell you the exact amount of gold that is in it' this implies that the miners are no longer interested in mining alone but mining minerals that are of high grade. The low grade minerals may therefore be abandoned at expense of the high grade minerals. The effect on deforestation will subsequently be reduced so also the destruction of the land surface.

In the nearest future, it is believed that the miners will be fully organized into a registered mining society/organization. This will legalize their activities and make it easy to tame the miners. The environmental impact assessment (EIA) will also be jointly carried out by both the communities and the miners. Though some communities are awake to the effect of inadequate EIA as observed in a letter by Igala Environmental Monitoring Group, a coalition of the Igala Advancement Foundation, Igala Association United Kingdom (UK), Igala Association, USA and other well-meaning Igala sons and daughters led by Alhaji Abdullahi Ibrahim (SAN) to the Permanent Secretary, Federal Ministry of Environment (Daily Champion, March 7th, 2011). The group claims that some of the villages reported to be in Benue State in the EIA are in Kogi State hence decry the fact that EIA was actually carried out.

7. MATERIALS HANDLING

In materials handling, the design and proper operation of clearance systems for transporting mined materials from the point of mining to processing locations are critical for enhanced production. The major problem in the development of continuous haulage for underground mining is maneuvering corners. Therefore, research should also focus on automated roof bolting and integration with cutting and hauling functions.

Reducing the amount of material hauled from underground mines by clearly identifying the waste and ore components at the mine face would result in both energy and cost savings, as well as reduction in the amount of waste generated. For this purpose, the development of ore-grade analyzers to quantify the metal and mineral contents in the rock faces would be extremely useful. Similarly, in surface mines, the down-hole analysis of ore in blast holes could lead to more efficient materials handling by identifying ore and waste constituents.

Equally important to improving the performance of materials-handling machinery will be development of new technologies for monitoring equipment status and for specific automation needs. Transporting ore for processing can take considerable time and energy and can contribute significantly to the overall cost of production in both surface and underground mining operations. An area for exploratory research should be downstream processing while the ore is being transported. For certain processes, transport by conveyor-belt systems and hydraulic transport through pipelines would allow for some processing before the ore reaches the final point of processing.

8. CASE STUDY 1: A CASE OF 5 COMMUNITIES (X) AND A QUARRY COMPANY (Y)

The case of these communities and the quarrying company involved is still on-going hence, the communities and the company will be referred to as X and Y respectively.

The X communities are located in Akinyele Local Government area of Oyo State, Nigeria. It is a new development area with growing population, and hosts a quarry. The mining company Y is involved in the quarrying of rocks which is further broken down to gravel sizes. The effects of the quarrying activities as listed in the address delivered at the State House of Assembly on July 29, 2008 are the following: "the blasting distance to the urban area is less than 500m. The ground vibrates due to the magnitude depth and interwoven nature of the rocks being quarried and the explosives being used to blast. These series of ground vibrations resulted in the cracking and weakening of the DPC". This vibration from the geological point of view causes differential soil settlement which is manifested in the cracked wall, decking and fences. The flying rocks at every instance of blasting are usually scattered in the environment thereby inducing fear in the mind of the residence as this could result in death when hit by the flying rocks.

Air blast noise is also reported to be frightening and terrifying, affecting the health of both the old and the young alike. This has resulted into death of hypertensive individuals in the communities while many suffer nightmare and insomnia in the surrounding communities. The emitted dust and gases that accompany blasting is said to have contaminated the water and air in the environment. Taking cue from Alakia and its environs also in Oyo State, the aftermath effect of the mining may include lake formation as a result of drilling, possibilities of flood and erosion and the fear of land slide and tremor. At present, the production has stopped in the company due to agitation from the communities.

9. CASE STUDY II: THE ILLEGAL MINERS IN NDEJI

These miners have organized themselves into a small community with a leader. They specialize in mining microlite (*kuli-kuli*), green tourmaline and gold. The extractions are carried out using digger, shovel and bucket essentially (Fig. 3) with bull-dozers (Fig. 4), excavator and pumping machine. The lost minerals are recovered using a traditional method (Fig. 5). This operates based on gravity settling. The miners believe that they own the land and see the government as their "enemy". The miners mine for themselves and sell their products within or outside the mine site. Some of the effects of their activities as seen during the visit are deforestation (Fig. 4), destruction of surface textures, and pollution. The miners carry out their extraction by burrowing (Fig. 6) without considering the rock mechanics. As observed, some of the area is fractured. The fractured areas have been abandoned because of the fear of land slide and they moved to other areas a few meters from the fractured site.

It can be concluded that in the nearest future, the mining area will quake and this may result in death of the inhabitants. The area will also be eroded. Other conspicuous effect on the environment is the pollution of the rivers that drain the area. The streams are used in the extraction of microlite, etc from the gangue. The formation of artificial lake is eminent in the area because of depressions already created (Fig. 7). The people living downstream are equally affected with the polluted water.



Figure 3 Field photograph of illegal miners exploring for tantalite at Ndelji



Figure 4 Field photograph of Bulldozer used for land clearing at Ndelji



Figure 5 Field photograph showing the exploitation of Microlite (Kuli-kuli) in Ndelji



Figure 6 Field photograph showing the tunnel dug by the miners (*See the arrow*).



Figure 7 The pit dug by the miners in Ndelji

10. CONCLUSION

From the discussion held with the miners and the literature reviewed, the need to diversify the Nigeria's economy and the prevailing climate change across the globe, it may be concluded that the absence of legalized mining companies gave rise to the influx of artisanal and illegal miners in Nigeria. Some of the legalized miners quit the business either because of the declining price of the minerals in the world market or the civil unrest in their host communities. It can also be concluded that the mining exercise in Nigeria in the nearest future will be mineral and site specific. The industrial demand for some of the metals will be met through recycling of the waste materials hence the net exploitation may not be to meet the industrial needs. Furthermore, the government should remove her bottleneck process of securing the mining documents so that the miners can easily organize themselves into societies that will be registered and regulated. She should make all effort to ensure that environmental management and rehabilitation are incorporated into the mining plan. The cost of managing the environment is relatively cheaper when incorporated at the planning stage than after the mine life span. The land reclamation should be carried out in partnership with the local communities.

Government should also be grossly involved in providing information on the environmental impacts that may ensue from the mining activities in the country and the best technique to arrest these impacts should be readily made available to the miners and the communities that are likely to be affected as well for their information.

It is recommended that the government should enact laws that will compel the miners or mining companies to adopt environmentally friendly techniques in the exploitation of the natural resources in all phases of their activities. The mining company should also be forced to adopt risk analysis and risk management including handling of toxic waste in their operations. While the government should try and train people on environmental management in relation to mineral exploitation, she should also compel the mining companies to recognize the relationship between the people, culture, safety, local communities and their environment.

Conflict of Interest

None

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